Designation: F3565 – 23

An American National Standard

Standard Practice for Electrofusion Joining Polyethylene (PE) Pipe and Fittings for Pressure Pipe Service[1]

This standard is issued under the fixed designation F3565; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 This practice describes procedures for making joints suitable for pressure service with polyethylene (PE) pipe and fittings by means of electrofusion joining techniques in, but not limited to, a field environment. Other suitable electrofusion joining procedures are available from various sources including fitting manufacturers. This standard does not purport to address all possible electrofusion joining procedures, or to preclude the use of qualified procedures developed by other parties that have been proven to produce reliable electrofusion joints. (Note 1)

NOTE 1—Reference to the manufacturer in this practice refers to the electrofusion fitting manufacturer.

1.2 The parameters and procedure are applicable only to joining polyethylene pipe and fittings (Note 2) which are intended for PE fuel gas pipe per Specification D2513 and PE potable water, sewer and industrial pipe manufactured per Specification F714, Specification D3035, Specification F2619, and AWWA C901 and C906.

NOTE 2—Commercially available materials classified with a thermoplastic pipe material designation code beginning with PE 14, PE 23, PE 24, PE 27, PE 33, PE 34, PE 36, and PE 46, and PE 47 in accordance with Specification D3350 and Terminology F412 are generally acceptable for electrofusion joining using this practice. Consult with the pipe or fitting manufacturer for specific compatibility information.

1.3 Parts that are within the dimensional tolerances given in present ASTM specifications are required to produce sound joints between polyethylene pipe and fittings when using the joining techniques described in this practice.

1.4 The values stated in inch-pound units are to be regarded as standard. The values given in parentheses are mathematical conversions to SI units that are provided for information only and are not considered standard.

1.5 The text of this practice references notes, footnotes, and appendices which provide explanatory material. These notes and footnotes (excluding those in tables and figures) shall not be considered as requirements of the practice.

1.6 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety, health, and environmental practices and determine the applicability of regulatory limitations prior to use.*

1.7 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

D1600 Terminology for Abbreviated Terms Relating to Plastics

D2513 Specification for Polyethylene (PE) Gas Pressure Pipe, Tubing, and Fittings

D3035 Specification for Polyethylene (PE) Plastic Pipe (DR-PR) Based on Controlled Outside Diameter

D3350 Specification for Polyethylene Plastics Pipe and Fittings Materials

F412 Terminology Relating to Plastic Piping Systems

F714 Specification for Polyethylene (PE) Plastic Pipe (DR-PR) Based on Outside Diameter

F1055 Specification for Electrofusion Type Polyethylene Fittings for Outside Diameter Controlled Polyethylene and Crosslinked Polyethylene (PEX) Pipe and Tubing

F2619 Specification for High-Density Polyethylene (PE) Line Pipe

2.2 *PPI Documents:*[3]

TR-49 Generic Electrofusion Joining Guide for Field Joining of Polyethylene Gas Pipe

[1] This test method is under the jurisdiction of ASTM Committee F17 on Plastic Piping Systems and is the direct responsibility of Subcommittee F17.20 on Joining.

Current edition approved Sept. 1, 2023. Published September 2023. DOI: 10.1520/F3565-23

[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

[3] Available from Plastics Pipe Institute (PPI), 105 Decker Court, Suite 825, Irving, TX 75062, http://www.plasticpipe.org.

2.3 *AWWA Documents:*[4]

AWWA C901 Standard for Polyethylene (PE) Pressure Pipe and Tubing, ½ in. (13 mm) through 3 in. (76 mm), for Water Service

AWWA C906 Standard for Polyethylene (PE) Pressure Pipe and Fittings, 4 in. (100 mm) through 63 in. (1575 mm), for Water Distribution and Transmission

3. Terminology

3.1 *Definitions*—Definitions are in accordance with Terminology F412, and abbreviations are in accordance with Terminology D1600, unless otherwise specified.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *control box, also referred to as processor*—the apparatus placed between the power source and the electrofusion fitting to regulate voltage or current input to the fitting for the specified time or energy defined by the electrofusion fitting fusion parameters.

3.2.2 *operator*—an individual that has been evaluated and found to be qualified to make electrofusion joints in accordance with this standard.

3.2.3 *pipe end*—the end of a length of pipe or fitting spigot end having pipe dimensions such as a tee, elbow, valve, etc.

3.2.4 *peeler*—a pipe surface preparation tool that is designed to remove a controlled amount of outer pipe surface or pipe end material in a continuous ribbon during the pipe preparation process for electrofusion joining.

3.2.5 *scraper*—a pipe surface preparation tool that uses a smooth or serrated blade that is dragged over the pipe surface to scrape away outer pipe or pipe end material during the pipe preparation process for electrofusion joining.

4. Significance and Use

4.1 Using the procedures and apparatus in Sections 8 and 9 and the manufacturer's instructions, pressure-tight joints as strong as the pipe itself can be made between manufacturer-recommended combinations of pipe and fittings. See Specification F1055 for performance requirements of polyethylene electrofusion fittings.

5. Operator Experience

5.1 Skill and knowledge on the part of the operator are required to obtain a good quality joint. The skill and knowledge are obtained by making joints in accordance with proven procedures under the guidance of qualified evaluator.

5.2 Each operator shall be qualified in accordance with recommended procedures and any regulatory agency or industry organization that has jurisdiction over these practices. For gas applications, qualification of the procedure by testing joints made using the procedure in accordance with regulations from the authority having jurisdiction are required.

5.3 The party responsible for the joining of polyethylene pipe and fittings shall ensure that detailed procedures developed in conjunction with applicable codes and regulations and the manufacturers of the pipe, fittings, and joining equipment involved, including the safety precautions to be followed, are issued before actual joining operations begin.

5.4 These procedures require the use of electrical and mechanical equipment. The operator shall ensure that recommended procedures developed for the electrofusion fittings involved, including the safety precautions to be followed, are issued before joining operations commence. It is especially important that the operator be aware of specific instructions regarding the use of electrical equipment in the presence of a potentially explosive environment.

6. Electrofusion Joining Processes

6.1 Electrofusion is a heat-fusion joining process where the heat source is a resistance wire heating element that is an integral part of the fitting. Energy is supplied to the resistance wire by a control box that supplies voltage determined by input of fusion parameters through *(1)* a barcode on the fitting that is scanned by the control box or *(2)* an identification device that is integral to the fitting and sensed by the control box or *(3)* manual entry of the fusion parameters by the operator. When energy is applied, heat is produced, melting and joining the components. As the polyethylene pipe and fitting surfaces melt they undergo volumetric expansion that closes annular spaces between the pipe and fitting. Continued melt expansion generates pressure within the heated zones. The expanding melt reaches areas within the fitting where heat is not produced, called cold zones, allowing the leading edges of melt flow to cool and solidify, thereby blocking any further melt movement or escape. The heating process continues for a predetermined time so that substantial pressure is reached through continued melt expansion in the contained melt pool of the pipe and fitting surfaces, also known as the joint. Fusion occurs when the pipe and fitting materials mix together and the joint cools below its melt temperature co-crystallizing into a homogenous monolithic structure. Maximum joint strength has occurred when the joint reaches ambient temperature

6.2 Electrofusion fitting manufacturers establish and qualify ambient temperature joining limitations for their fitting designs. Verify the acceptable installation temperature limit with the fitting manufacturer.

7. Classification

7.1 *Technique 1: Socket Type*—The electrofusion socket technique involves heat fusion of pipe or pipe ends with a fitting utilizing socket ends with a pipe section or pipe end inserted in each end of the fitting. The sockets contain a resistance wire coil located on the inner surface that acts as an internal heat source. When voltage is applied, heat is produced to melt the inside of the fitting and the outside of the pipe. An alignment device or method shall be used to secure the joint and hold it in axial alignment during the joining process. The device or method may be either external or one that is integral to the fitting itself.

7.2 *Technique 2: Saddle Type*—The electrofusion saddle technique involves heat fusion of a saddle fitting to the outer surface of a pipe. The heat source is a resistance coil and is

[4] Available from American Water Works Association (AWWA), 6666 W. Quincy Ave., Denver, CO 80235, http://www.awwa.org.

located on the fusion surface of the concave base of the saddle fitting. When voltage is applied, heat is produced at the interface of the pipe and fitting, melting the surfaces of the two components. A restraining device is used to hold the fitting in place on the pipe during the fusion process. The device may be either external or one that is integral to the saddle fitting itself.

8. Apparatus

8.1 *General Recommendations:*

8.1.1 *Power Source*—An adequate source of electricity is required. Consult the manufacturer's recommendations for the type of power (ac or dc), input voltage, frequency (Hertz) and power output (kW) required for proper fusion of fittings. A transformer may be required if the source voltage differs from the voltage recommended by the manufacturer.

8.1.2 *Extension Cord*—If the power source is remote from the installation site, an extension cord may be required. Select an extension cord following manufacturer's recommendations of sufficient conductor size to deliver the required voltage to the control box.

8.1.3 *Control Box*—A control box is required to deliver the appropriate amount of energy to the electrofusion fitting. Control boxes incorporate *(1)* a barcode scanning device that reads the input parameters on the electrofusion fitting, or *(2)* a means of sensing a value provided by the electrofusion fitting that determines the fusion parameters, or *(3)* allow manual input of the fusion parameters. Not all control boxes are compatible with all electrofusion fittings. Consult the fitting manufacturer to determine the compatibility of control boxes not made by the same manufacturer as the fitting.

8.1.4 *Alignment Device or method*—Alignment control is required for electrofusion. Various types of alignment and clamping devices or methods are available. The device or method will align and restrain the pipe and fitting being joined during the fusion and cooling cycles.

8.1.5 *Surface Preparation Equipment*—The purpose of surface preparation is to remove surface contamination and oxidation from the pipe or pipe ends prior to assembly and fusion. A surface removing tool is required to remove the outer layer of material on the pipe or pipe end surface prior to fusion. Tools used for this purpose are commonly called peelers or scrapers. Only qualified procedures and tools intended to prepare the pipe surface shall be used. Emery cloth or sandpaper is not acceptable and shall not be used. (Note 3).

NOTE 3—Pipe surface preparation is very important to ensure total fusion. Not all surface preparation tools perform equally. Tools such as peelers that are designed to remove a controlled and measurable amount of surface material are recommended. Tools should be inspected for proper function and cleanliness before each use to ensure proper surface layer removal depth and to prevent accidental introduction of potential contaminants. Witness marks made on the pipe surface to be prepared can visually aid the installer in verifying that the surface is properly prepared.

8.1.6 *Additional Equipment*—The following equipment is also used in the electrofusion joining procedures described below:

8.1.6.1 *Tubing/Pipe Cutter*—Used to obtain square end cuts on pipe.

8.1.6.2 *Marking Pen*—A permanent marker of contrasting color to the pipe is used to mark the fitting location on the pipe surface. The marker shall be of a type that is fast drying and contains no additives such as greases or other petroleum bases that may hinder the fusion process. A marking pen is used to define the boundaries before peeling or scraping the pipe surface.

8.1.6.3 *Cleaning Solvent*—A 90 % or greater concentration of isopropyl alcohol in water. No other additives may be present in the isopropyl alcohol solution. Acetone has been evaluated as a cleaning solvent and is an acceptable alternate to isopropyl alcohol.

8.1.6.4 *Wiping Cloth*—A clean, dry, low-lint cloth or paper towel should be used for removing surface preparation residue from the joining surfaces. Packaged 90 % or greater isopropyl alcohol wipes are also suitable. Considerations of the hazards of static electricity should be applied in selection of a wiping cloth material.

8.1.6.5 *Rerounding Devices*—Rerounding equipment is used to bring the pipe into the out of round limitation requirements of the applicable pipe standard or the limitations established by the electrofusion fitting manufacturer, whichever is more severe. (Note 4)

NOTE 4—Some alignment devices may also be capable of rerounding pipe ends.

8.1.6.6 *Witness Mark Scribing Device*—A device that scribes a mark on the surface to be prepared for electrofusion joining that aids the installer in determining that the minimum amount of surface has been removed by scraping. The depth of the mark is controlled to an amount that is slightly less than the minimum recommended pipe surface material removal depth so that complete removal of the scribed mark visually ensures that adequate material has been removed during pipe preparation.

9. Joining Procedure

9.1 *Precaution*—Fusion quality can be affected if extreme weather conditions exist such as high winds, blowing dust and dirt, and wet conditions (see 6.2 for information regarding installation temperature limits). Ambient temperature limitations of the electrofusion control box and fitting should be considered when making field joints. Observe normal precautions in the use of electrical equipment, especially in wet environments.

9.1.1 *Fitting handling and storage*—Electrofusion fittings are packaged in sealed plastic bags. This packaging is intended to provide some protection from dirt and contamination during normal storage and handling, but it is good practice to inspect and clean electrofusion fitting fusion surfaces with a cleaning solvent and a wiping cloth before use. Avoid touching fitting and prepared pipe fusion surfaces with hands because body oils can affect fusion quality.

9.2 *Technique 1: Socket Procedure:*

NOTE 5—When electrofusion fittings are to be used to repair pipe under conditions where line pressure buildup in the fusion joint is anticipated, pressure should be blocked off or vented to prevent excessive pressure buildup during the joining and cooling cycle.

9.2.1 Cut the pipe ends squarely and remove burrs or shavings. Inspect for damage, gouges, out of roundness, and embedded debris such as rocks that might damage scraping/peeling tools.

9.2.2 If pipe exceeds fitting manufacturer recommendations for pipe out of roundness, utilize a re-rounding device to conform the pipe to fitting manufacturer's tolerances.

9.2.3 Establish a water-wash clean area on the pipe end long enough to accommodate the fitting and solvent wash clean areas as shown in Fig. 1. Water (detergent free) should be used to remove dirt and mud from the pipe in this step. Mark the boundary of the clean zone on the pipe end and ensure that subsequent cleaning does not exceed this established zone (Note 6). Clean and dry the inside and outside of the pipe ends with a clean wiping cloth. Clean the pipe exterior all the way to the marked clean zone boundary.

NOTE 6—The purpose of separately defined clean areas is to ensure that debris or other contaminants on the pipe surface are not transferred to the area to be prepared for fusion. A clearly defined water-wash area and solvent-wash area are established so that accidental spreading of contamination onto already cleaned surfaces is minimized when cleaning with solvent in later steps.

9.2.4 Within the water-wash clean area, mark another area longer than the area to be scraped/peeled. This area is the solvent-wash area. Clean this area with a solvent and clean wiping cloth, unless the operator determines solvent cleaning is not necessary. Clean all the way to, but do not exceed the marked boundary of the solvent-wash area when cleaning during this or later steps. Allow to dry completely before proceeding.

9.2.5 Mark the length of the area to be scraped/peeled on the pipe end beyond the scrape/peel area, so that it is slightly longer than the fitting socket depth. Additional witness marks on the pipe surface should be made within the marked scrape/peel area. These marks are used as a visual aid after scraping/peeling where any visible marks remaining on the pipe indicate that an adequate amount of the pipe surface was not removed and further scraping/peeling is required. See Fig. 1 for example of water-wash, solvent-wash, and scrape/peel marking.

9.2.6 Remove the outer surface of the pipe by scraping or peeling. The use of scrapers not designed for this purpose should be avoided unless the tool has been qualified to ensure that the tool removes a consistent, controlled and measurable amount of outer surface. Avoid gouging or removing excessive material from the pipe surface. Do not touch the prepared pipe or fitting surfaces after scraping or peeling.

9.2.7 If incidental contamination occurs, cleaning of the prepared surface is allowable with a solvent and clean wiping cloth. Clean all the way to, but do not exceed the prepared surface. Exceeding the prepared surface may reintroduce contamination. Allow to dry completely before proceeding. (Note 7)

NOTE 7—Witness marks from a scribing device that are physically scribed into the pipe surface to a controlled depth that is then removed by scraping / peeling are positive visual indicators that the minimum amount of pipe surface material has been removed. Any witness marks remaining in the scrape/peel area are indication that additional scraping is required. Alternately, when peelers are used, the thickness of the ribbon removed from the pipe surface can be measured to ensure that the minimum amount of pipe surface has been removed.

9.2.8 Measure the depth of the fitting socket and transfer a mark onto the pipe end equal to that distance. This mark is the stab depth mark and is used to indicate that pipe is fully inserted into the fitting socket once assembled. (Note 8)

9.2.9 Promptly after preparing the pipe surface, remove the fitting from the plastic bag and center the fitting on the pipe ends so that both stab depth marks are visible against the fitting socket entrance. (Note 8)

NOTE 8—Care should be taken to ensure that fitting and pipe joint surfaces are properly handled and maintained free of contamination, such as dirt, debris, or other sources of contamination such as oil from the operator's hands which could have a deleterious effect on joint quality. Avoid touching the fusion zone of the fitting and prepared pipe fusion

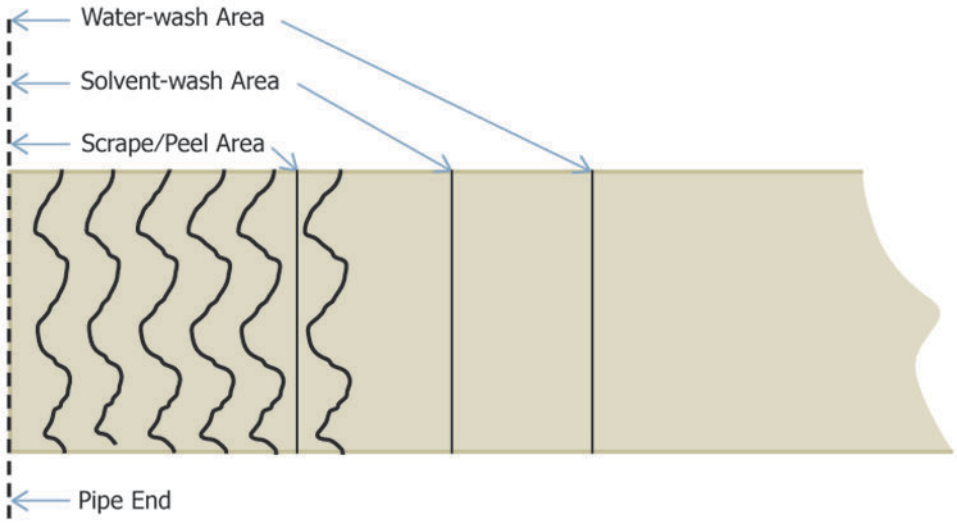

FIG. 1 Clean Zones